UNEARTHING THE ENVIROMENTAL IMPACT OF HUMAN ACTIVITY : A GLOBAL CO2 EMISSIONS ANALYSIS

1 INTRODUCTION

1.1 OVERVIEW

Carbon dioxide (CO_2) is released into Earth’s atmosphere mostly by the burning of carbon-containing fuels and the decay of wood and other plant matter. Under all conditions found naturally on Earth, CO_2 is an invisible, odorless gas. It is removed from the atmosphere mostly by plants, which extract carbon from CO_2 to build their tissues, and by the oceans, in which CO_2 dissolves.

Because CO_2 is opaque to infrared radiation (the electromagnetic waves emitted by warm objects) in the atmosphere, it acts as a blanket to slow the loss of heat from Earth into space. Although other gases are also causing Earth's climate to warm, CO_2 alone is responsible for about three-fourths of global warming.

The amount of CO_2 in the atmosphere has increased greatly since human beings began burning large amounts of coal and petroleum in the nineteenth century. In more recent times, this source of CO_2 emissions has increased rapidly, while destruction of forests has also become a major source of CO_2. Atmospheric concentrations of several other gases, including methane (CH_4) and nitrous oxide (N_2O), have also been increased recently by human activities and are contributing to greenhouse warming of the planet.

Historical Background and Scientific Foundations

Emissions of CO_2 predate the human race by billions of years and are essential to life on Earth, since the natural greenhouse effect keeps Earth's average surface temperature above freezing. In the deep geological past, atmospheric CO_2 has sometimes been much higher than today; for example, about

500 million years ago there was over 15 times as much atmospheric CO_2 as there is now. On the other hand, until human beings began to burn large amounts of fossil fuel in the late eighteenth century, CO_2 had been stable for about 20 million years. Due to anthropogenic (human-caused) emissions, atmospheric CO_2 is now significantly higher than at any time in the last 800,000 years and probably in the last 20 million. This change has happened in a mere 200 years, which is instantaneous by geological standards.

The atmospheric CO_2 record of the last 800,000 years is known precisely because layers of snowfall in Greenland and Antarctica can be counted like tree rings, and air bubbles in the layers preserve samples of the ancient air. For even more ancient times, geologists must rely on various chemical traces that atmospheric processes have left in the rocks and fossils. These traces do not provide as high-resolution a record as do ice cores.

In 1750, CO_2 was present in the atmosphere at about 280 parts per million or ppm (that is, 280 out of every 1 million molecules in a typical volume of air were CO_2 molecules). By 2008, atmospheric CO_2 was up to about 385 ppm, an increase of 37.5% over pre-industrial times.

Atmospheric CO_2 has been measured steadily ever since 1958, when American geochemist Charles David Keeling (1928–2005) made the first such measurements at Mauna Loa Observatory in Hawaii. Keeling found that, month by month, atmospheric CO_2 tracks the growing season in the Northern Hemisphere, which contains most of the world's land area and therefore most of its plants. In the spring and summer, as green plants grow, they remove CO_2 from the air; in the winter, plant decay continues to release CO_2 while growth absorbs relatively little. The result is a series of peaks and valleys in atmospheric CO_2. From the top of each winter peak to the bottom of each summer valley, CO_2 concentration decreases by about 5 ppm; from summer to winter, it increases by about the same amount.

1.2 PURPOSE

Global emissions of carbon dioxide have more than doubled since 1971, increasing on average 2% per year. In 1971, the current

OECD countries were responsible for 67% of world CO_2 emissions. As a consequence of rapidly rising emissions in the developing world, the OECD contribution to the total fell to 37% in 2013. By far, the largest increase in non-OECD countries occurred in Asia, where China’s emissions of CO_2 from fuel combustion have risen, on average, by 6% per annum between 1971 and 2013. Driven primarily by increased use of coal, CO_2 emissions from fuel combustion in China increased over tenfold between 1971 and 2013. Two significant downturns in OECD CO_2 emissions occurred following the oil shocks of the mid-1970s and early 1980s. Emissions from the economies in transition declined in the 1990s, helping to offset the OECD increases between 1990 and the present. However, this decline did not stabilise global emissions as emissions in developing countries continued to grow. With the economic crisis in 2008/2009, world CO_2 emissions declined by 2% in 2009. However, growth in CO_2 emissions have rebounded, with emissions increasing by 1% in 2012 and 2% in 2013. Disaggregating the emissions estimates shows substantial variations within individual sectors. Between 1971 and 2013, the combined share of electricity and heat generation and transport shifted from one-half to two-thirds of the total. The share of the respective fuels in overall emissions also changed significantly during the period. The share of oil decreased from 48% to 34%, while the share of natural gas increased from 15% to 20% and that of coal in global emissions increased from 38% to 46%. Fuel switching, including the penetration of nuclear, and the increasing use of other non-fossil energy sources only reduced the CO_2/total primary energy supply ratio by 6% over the past 40 years.

4 ADVANTAGES

Reducing Greenhouse Gas Emissions

the overall slowed climate change and environmentally beneficial practices that will be implemented. Climate change is the central cause of increased droughts, sea-level rise, drastic weather events, such as forest fires, and all the subsequent devastating effects of these events on humanity and our development in every sense. Reducing GHG emissions is the number one key to working towards a cleaner, greener, safer, and healthier society around the globe.In addition to these tangible global, large-scale benefits, organizations can also benefit from the positive impacts of greenhouse gas emission reduction. The biggest benefits of effective emission management include:

4) Cost Savings

When it comes to cost savings, the simple reduction of energy usage both shrinks your organizational carbon footprint and your operating expenses themselves. In 2016, Energy Star released a report – when Intelligent Energy Optimizers LLC (IEO) supplied LED lighting to replace the existing fluorescents and HIDs at Kimberly–, Clark Berkley Mill, an investment of $350,000 by the owner resulted in annual savings of $160,000 with full ROI in just over one and a half years.

5) Improved External Relations

The spending power of consumer populations holds immense sway in the process of influencing organizational action. The process of commitment to accountability in the arenas of broader sustainability as well as greenhouse gas emission reduction is a huge credibility boost in the eyes of the public. When your organization takes direct actions towards reducing carbon dioxide and greenhouse gas output, the causal increase in quality and depth of relationships with potential partners and external business connections is invaluable.

6) Improved Stakeholder Relations

Alongside the deepened relationship with the public, the impact of transparent sustainability metrics and performance holds immense potential to deepen invaluable relationships with stakeholders. More investors than ever before are diverting capital away from carbon-heavy, secretive companies, and turning towards those who chose to be open, proactive, and honest with their management of greenhouse gas emissions within the sustainability world, and beyond.

7) Regulatory Compliance

With a 20-fold increase in the amount of global climate change laws since 1997, ensuring proactive regulatory compliance is more prevalent in the minds of organizational leadership, public spheres, and stakeholders than ever before – and it’s only rising in importance. Implementing an effective greenhouse gas emission reduction strategy, as well as documenting and reporting on progress in that area, is a vital action for organizations to take in order to continue operations and reduce fines.

Ways to Reduce Greenhouse Gas Emissions

When it comes to the act of actually reducing these GHG emissions, there are several paths you can take – and the more angles you approach while working to solve the issue of effective greenhouse gas emission reduction, the more effective your final efforts will be.

- Cut initial consumption of energy
- Replace fossil fuels with cleaner, greener alternatives
- Work towards higher energy efficiency rates
- Purchase carbon offsets

Cut Consumption

Simply trying to decrease the amount of energy and supplies your organization is using during its daily operations can have a huge impact on the effectiveness of greenhouse gas emission reduction programs.

Clean Fuel Alternatives

With electric vehicles, innovations in solar energy, and countless more options available within the scope of moving away from fossil fuels and coal as primary sources of energy – as well as huge subsequent benefits when it comes to ROI and environmental protection – there's really no downside to working towards using only clean fuel.

Energy Efficiency

When the reduction of operating costs, as well as emission reduction, hinges on the simple act of investing in more energy-efficient equipment, the decision is simple. Committing to the installation of more energy-efficient systems throughout a company's functioning areas, whether retail, production, warehouse or something entirely different, is the way to go.

Carbon Offsets

A carbon offset is a reduction in emissions of greenhouse gases made in order to compensate for emissions made by your company. The money used to purchase these offsets is used to finance projects – forest preservation, energy efficiency efforts, and landfill methane capture – that would not have been built without that investment and funding. Read more about carbon offsets and how to purchase them.With these strategies under your belt, supporting the environment we live in as well as pushing towards the next level of excellence within your organization is more accessible than ever before. Don't let the opportunity pass you by – invest in energy-efficiency and sustainability efforts for your business and join the march towards universal greenhouse gas emission reduction today.

DISADVANTAGES

A 2017 study found that in China, 1.23 million air pollution-related deaths in 2010 represented up to 13.2% of the country's GDP. In the same year, air pollution caused over 23 000 deaths in the UK, representing up to 7.1% of the GDP. Another report projects that annual premature deaths due to outdoor air pollution will increase to up to 9 million people in 2060 from 3 million in 2010, as well as an increase in annual global hospital admissions: 11 million people in 2060 from 3.6 million people in 2010. One of the biggest benefits of reducing carbon emissions is that it would decrease the number of deaths related to air pollution and help to ease pressure on healthcare systems.

To achieve growth in the economy while still prioritising the reduction of carbon emissions, a decoupling between the two is needed. There are a variety of ways this can be done; a notable example is implementing a carbon tax.

Carbon taxes are seen as a way to reduce emissions, while making the economy more efficient, and are advocated as a means to improve the operation of the economy, lower dependence on foreign fossil fuels (for importing countries), reduce pollution and cut government spending. Over the last 20 years, Sweden has proven this with their carbon tax; announced in 1991, the price of carbon has risen steadily from €29 to €125 in 2014. Globally, Sweden has the highest level of carbon taxation in the world and has been able to achieve decoupling. The revenue from this tax is used wherever the country needs it.

China is the highest global emitter of carbon and experiences high levels of air pollution. In 2010, China's Low-Carbon Pilot Policy (CLCP) was implemented in five provinces and eight cities aimed at decoupling economic growth from fossil fuel use by shifting to an economy based on energy efficiency and renewable energy. While the pilot cities have made progress in establishing low-carbon plans, there are barriers such as a lack of explicit definition for 'low-carbon city', confusion resulting from several parallel programs, and insufficient supporting policies. However, the CLCP promotes regional economic growth and while it increases production costs, it also promotes the growth of enterprises' output and benefits. Additionally, it helps to strengthen internal management, efficiency and innovation, which fosters competitiveness and higher productivity. A 2019 study shows that as a result of the CLCP, the degree of competitiveness in markets has been magnified, encouraging economic growth by not only selling products at competitive prices, but also driving for innovation. This is clearly evident in July 2021 when China managed to launch a national emissions trading scheme after much delay. The market saw 4.1 million tonnes of carbon dioxide quotas worth USD$32 millions traded on the first day of its opening, making it the world's largest carbon market

A 2017 study claims the best way to avoid increasing production costs is for developers to produce new technologies that reduce CO_2 emissions while also decreasing costs. According to the National Statistics, as a result of not only climate regulation and economic structural change, but also technological advancements that took place in the UK, the region was able to achieve decoupling between 1985 and 2016 with GDP per head rising by 70.7% while emissions dropped by 34%. These technological advancements involved developments in vehicle efficiency and replacement of fossil fuels with renewable energy; between the years 1990 and 2017, the use of energy from renewable sources grew by 1 267% while fossil fuel consumption decreased by 22%. Denmark's rapid increase in renewable energy reduced emissions while encouraging local production.

Conversely, productivity is negatively affected by the climate crisis through the loss of infrastructure through disasters like flooding, sea level rise and the hampering of agriculture.

A study in the journal, Nature, says that for each trillion tonnes of CO_2, GDP losses could be nearly half a percent. Developed countries such as Canada, Germany, New

Zealand and the UK will have less than 0.1% of productivity loss per unit emission. However, productivity losses in developing countries like India, Thailand and Malaysia will range from 3-5% of total GDP per year for every trillion tonnes of carbon emitted. Implicitly, keeping carbon emissions down would result in a reduction of productivity losses (the degree of reduction depending on the country).

Further, if we pursue all of the low-cost climate crisis abatement opportunities currently available, the total cost of mitigating the climate crisis would be 200-300 billion Euros per year by 2030 – less than 1% of the forecasted global GDP in 2030.

It is imperative that countries achieve this decoupling and reduce carbon emissions, ideally through a carbon tax, to ensure a more sustainable and prosperous economy. Failure to act, or acting too late, will result in even further climate breakdown, affecting any chance humanity has of extending its lease on the planet.

5 APPLICATIONS

New pathways to use CO_2 in the production of fuels, chemicals and building materials are generating global interest. This interest is reflected in increasing support from governments, industry and investors, with global private funding for CO_2 use start-ups reaching nearly USD 1 billion over the last decade.

The market for CO_2 use will likely remain relatively small in the short term, but early opportunities can be cultivated. The use of CO_2 in building materials is one such opportunity, but may require further trials and updating of standards for some products. Public procurement of low-carbon products could help to create early markets for CO_2-derived products with verifiable climate benefits.

CO_2 use has potential to support climate goals, but robust life-cycle assessment is essential. CO_2 use applications can deliver climate benefits where the application is scalable, uses low-carbon energy and displaces a product with higher life-cycle emissions. Quantification of these benefits can be challenging and improved methodologies are needed to inform future policy and investment decisions.

CO_2 could be an important raw material for products that require carbon. Some chemicals require carbon to provide their structure and properties while carbon-based fuels may continue to be needed where direct use of electricity or hydrogen is challenging (for example, in aviation). In the transition to a net-zero CO_2 emission economy, the CO_2 would increasingly have to be sourced from biomass or the air.
Globally, some 230 million tonnes (Mt) of carbon dioxide (CO_2) are used every year. The largest consumer is the fertiliser industry, where 130 Mt CO_2 is used in urea manufacturing, followed by oil and gas, with a consumption of 70 to 80 Mt CO_2 for enhanced oil recovery. Other commercial applications include food and beverage production, metal fabrication, cooling, fire suppression and stimulating plant growth in greenhouses. Most commercial applications today involve direct use of CO_2.

New pathways involve transforming CO_2 into fuels, chemicals and building materials. These chemical and biological conversion processes are attracting increasing interest from governments, industry and investors, but most are still in their infancy and face commercial and regulatory challenges.

The production of CO_2-based fuels and chemicals is energy-intensive and requires large amounts of hydrogen. The carbon in CO_2 enables the conversion of hydrogen into a fuel that is easier to handle and use, for example as an aviation fuel. CO_2 can also replace fossil fuels as a raw material in chemicals and polymers. Less energy-intensive pathways include reacting CO_2 with minerals or waste streams, such as iron slag, to form carbonates for building materials.

6 Conclusion

7 Future scope

If knowledge gaps are filled and various conditions are met, CO_2 capture and storage systems could be deployed on a large scale within a few decades as long as an explicit policy is put into place to substantially limit greenhouse gas emissions to the atmosphere.

A particularly critical issue remains that of incentives. If a “carbon price” is established for each unit of greenhouse gas emissions, this could create incentives to invest in processes which emit less greenhouse gases. CO_2 capture and storage systems are only likely to be widely adopted for power generation – the sector with by far the greatest potential – when the price of emitting a tonne of CO_2 exceeds 25–30 US$ (in 2002 dollars) over the lifetime of the project. A price on emitting CO_2 can only result from policy decisions for limiting CO_2 emissions. CO_2 capture and storage systems would be competitive with other large-scale mitigation options such as nuclear power and renewable energy technologies.

As part of a portfolio of actions to mitigate climate change, CO_2 capture and storage could reduce the cost of stabilizing the concentration of greenhouse gases in the atmosphere by 30% or more. Most scenarios for achieving such stabilisation at least cost estimate that the amount of CO_2 that could potentially be stored underground and in oceans during this century ranges between 220 and 2 200 $GtCO_2$. To achieve this potential, several hundreds or thousands of CO_2 capture and storage systems would be required worldwide over the next century, each capturing some 1 to 5 $MtCO_2$ per year. Such systems would need to be built in significant numbers in the first half of the century with the majority of them being built in the second half.

In the absence of measures for limiting CO_2 emissions, there would only be small, niche opportunities for carbon capture and storage technologies to deploy with a maximum potential of about 360 $MtCO_2$ per year. Such opportunities alone are unlikely to contribute significantly to the mitigation of climate change unless extended to the power sector.

Concerning long term leakage from storage, there must be an upper limit to the amount of leakage that can take place if CO_2 capture and storage is to be acceptable as a climate change mitigation measure. A fraction retained on the order of 90–99% for 100 years or 60–95% for 500 years could still make such impermanent storage valuable for the mitigation of climate change.